Remarks

The Examiner objects to claims 6 and 7 because they depend from a canceled claim. Claims 6, 7, and 8 have been amended to depend from claim 1. The Examiner objects to claim 10 because it has a duplicative article "the". Claim 10 has been amended to omit the duplicative article. Claims 15 and 22 have been amended to correct typographical errors. Applicant requests those amendments be entered and the application reconsidered.

In prosecuting this Application, much confusion has arisen regarding the meaning of the term "dielectric measurement". This is in part due to Applicant's attorney failing to appreciate the difference between a resistivity measurement and a dielectric measurement. Applicant's attorney apologizes for any confusion caused by his misstatements and hereby attempts, with the remarks below, to correct any misstatements and clarify the correct meaning of the term "dielectric measurement".

Those of ordinary skill in the art of well logging know there are certain logging methods that attempt to measure the resistivity of a substance and other methods that attempt to measure the dielectric permittivity of a substance. Resistivity and the dielectric permittivity are two different electromagnetic properties of a material and their methods of measurement are distinct. A resistivity measurement measures the resistivity of a material while a dielectric measurement measures the dielectric permittivity of a material.

The electrical resistivity of a substance is its ability to impede the flow of electrical current through the substance. More precisely, the resistivity of a substance is the resistance measured between opposite faces of a unit cube of that substance at a specified temperature. Typical units of resistivity are the ohm-meter (ohm-m). Conductivity is the reciprocal of resistivity and is expressed in siemens/meter (S/m) or the older units mhos/meter (mhos/m).

Most formations logged for the purpose of oil and gas exploration are made up of rocks that, when dry, will not conduct an electrical current. That is, the rock matrix has (essentially) zero conductivity or infinitely high resistivity. An electrical current will flow only (or at least mostly) through the interstitial water saturating the pore structure of the formation, and only then if the interstitial water contains dissolved salts. The dissolved salts dissociate into positively charged cations (such as Na^+) and negatively charged anions (such as Cl^-). Under the influence of an electric field, those ions move. The movement of those charges constitutes an electrical current. Other things being equal, the greater the salt concentration, the lower the resistivity of the formation water and, therefore, of the formation. Similarly, the greater the porosity of the formation and, hence, the greater the amount of formation water, the lower the resistivity.

The dielectric permittivity, on the other hand, is related to the ability of electric dipoles in a material to form and align themselves with an alternating electric field. Water molecules have large electric dipole moments and consequently the dielectric permittivity of water is high. It

is precisely this high dielectric permittivity, particularly as compared to oil, gas, and typical rock matrices encountered in hydrocarbon exploration, that dielectric measurements seek to exploit. The dielectric permittivity of water is generally an order of magnitude greater than the dielectric permittivities of the other formation constituents. Another important aspect, so far as hydrocarbon exploration is concerned, is the relative insensitivity of the dielectric permittivity of water to the salinity of the water, particularly at the typically high frequencies employed by dielectric-constant tools (the name commonly applied to tools used to make dielectric measurements). This is in stark contrast to the resistivity of the water, which varies over a wide range as a function of salt concentration.

The relatively high frequency used by dielectric-constant tools is another aspect distinguishing those tools from resistivity tools. Resistivity tools typically operate in frequencies ranging from a few kilohertz (say 20 kHz, for so-called induction resistivity tools) to a few megahertz (say 2 MHz). Contrast that with the 1.1 gigahertz frequency, for example, used in Schlumberger's EPT dielectric-constant tool. Dielectric-constant tools use microwave frequencies because the dielectric permittivity is essentially too small an effect to measure at the lower frequencies used by resistivity tools. That is, the use of higher frequencies is necessary to obtain a tool response that is sensitive to the dielectric constant (permittivity) of the formation. This can be better understood by comparing the relative magnitudes of the conduction current and the displacement current in Maxwell's equations. The dielectric constant enters Maxwell's equations as part of the displacement current. The conduction current and displacement current become of comparable magnitude at the higher frequencies, but at the lower frequencies commonly used in resistivity tools, the displacement current is negligible compared to the conduction current.

One final point regarding dielectric measurements is that they are often reported or characterized as formation traveltimes and amplitudes since those comprise an equivalent representation of the dielectric properties. One can show, for example, a relationship exists between the relative dielectric constant and the formation traveltime. This representation is generally more useful for practical log interpretation.

The Examiner rejects claims 1-4, 8, 10-12 and 30 as anticipated by Lew (US 4,785,245). The Examiner has taken the position that because oil can be characterized as a dielectric medium, any measurement performed on the oil is itself a dielectric measurement. (OA, p.2, ¶5.) That is simply not true and Applicant respectfully disagrees with the Examiner's conclusions. In particular, Applicant contends the Examiner's characterization of a "dielectric measurement" is incorrect. Under the Examiner's reasoning, measuring the temperature or pressure or color or taste of the oil would constitute a dielectric measurement. That is not an appropriate characterization of a dielectric measurement and one of ordinary skill in the art would not consider those measurements to be dielectric measurements. Thus, the Examiner's contention with respect to claims 1-4, 8, 10-12, and 30 that Lew teaches making or using dielectric measurements because Lew teaches making an NMR measurement on oil is not correct. An

NMR measurement on oil is not a dielectric measurement, regardless of whether the oil is itself a dielectric material.

The Examiner similarly argues Lew teaches acquiring a dielectric measurement of the earth formation by virtue of using rapid-pulse radio frequency (rf) transmissions designed to produce a response from only the oil portion of the fluid sample mixture. (OA, p.6, ¶18) Because the NMR rf emissions are, according to Lew, from the oil only, the Examiner characterizes this as a dielectric measurement. Again, that is not a dielectric measurement to one of ordinary skill in the art. The fact that a measured response stems from the oil alone does not make it a dielectric measurement. The measurement must provide an indication of the material's dielectric permittivity to be a dielectric measurement. The NMR response measures, for example, the relaxation time of the excited hydrogen nuclei within the oil and the hydrogen index, but not the dielectric permittivity of the oil. Thus, the Examiner's contention with respect to claims 1-4, 8, 10-12, and 30 that Lew teaches making or using dielectric measurements because Lew teaches making an NMR measurement on oil is not correct because, as stated above, an NMR measurement on oil is not a dielectric measurement, regardless of whether the oil is itself a dielectric material.

The Examiner further contends Lew teaches determining an oil volume fraction of the earth formation from a combination of the nuclear magnetic resonance measurement and the dielectric measurement. Applicant again respectfully disagrees. Lew in no way teaches or suggests making any type of dielectric measurement, much less combining those measurements. Lew is solely concerned with and only teaches making NMR measurements. This can be seen throughout Lew's disclosure, but is most readily apparent in the first line of Lew's Abstract ("...by use of NMR analysis"). In addition, Lew does not teach or suggest making measurements on an earth formation as required by Applicant's claims. Lew teaches a sampling tool that performs NMR-only measurements on fluids in a flowline. (Lew, Abstract, Sentences 1 and 2.) The fact that there may be soil components in the fluid mixture in no way equates to a measurement made on a formation itself.

Nor does Lew teach combining a bulk density measurement with an NMR measurement to determine the gas-fractional volume of the gas-liquid sample. Lew mentions certain prior art meters that use the bulk density of the total mixture and the bulk density of a degassed sample to measure water-cut (Lew, col. 2, ll. 28-39.) That does not constitute teaching the required combination of bulk density and NMR measurements claimed in claim 30 of the present application.

The Examiner rejects claims 1-3, 7, 10, 11, 14, 30, and 31 as obvious from Freedman (US 6,032,101). The Examiner relies on an unintentional misstatement by Applicant's attorney that a dielectric measurement was equivalent to a resistivity measurement. Applicant's attorney recants that statement and has clarified the nature of a dielectric measurement in the remarks made above. Because Freedman teaches resistivity measurements, not dielectric measurements, it is not a relevant reference. Thus, Applicants respectfully contends the

present invention is not obvious from Freedman and requests the Examiner to withdraw her rejection of these claims on that basis.

The Examiner also rejects claims 6, 7, 14, 31, and 32 as being obvious from Lew. The Examiner infers from Lew's teaching of detecting the fraction and net amount of oil in a flowing mixture on a continuous real-time continuum basis, as well as on an instantaneous basis, that Lew's device is installable in any oil well device, especially the logging while drilling tools. Applicant respectfully disagrees. Nowhere does Lew teach operating his device or performing his method in a downhole environment. The Examiner's inference ignores the harsh realities and challenges of the downhole environment. Lew's device is one specifically designed to perform the analysis on a flowing fluid. The mere fact that the analysis may be performed in real-time in no way suggests the device or method is operable downhole. Real-time monitoring from the surface is common practice among well operators. Thus, Applicant contends the present invention is not obvious over Lew and Lew fails to teach or suggest each and every element of Applicant's claims.

Similarly, Lew does not teach or suggest making measurements on an earth formation. The mere presence in the fluid sample of produced formation particulates such as "soil components" in no way equates to making a downhole measurement on an earth formation as required by Applicant's claims. Nor does Lew teach or suggest making dielectric or bulk density measurements or combining those measurements in any way, with or without NMR measurements. The mere mention of the term "dielectric" or the acknowledgement that prior art tools make bulk density measurements falls far short of teaching the invention claimed by Applicant and rendering it obvious.

Applicant's invention is neither anticipated nor obvious based on the cited references for at least the reasons stated above. Because the independent claims 1, 14, 28, and 32 are not anticipated or obvious, claims dependent from them are likewise not anticipated or obvious. In light of the arguments made, Applicant respectfully requests reconsideration of this application and favorable action with respect to claims 1-32.

The Commissioner is authorized to pay any additional fees or credit any overpayment to Deposit Account No. 19-0610.

Respectfully submitted,

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Date

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